



# Effect of Extreme Cold Treatment on Morphology and Behavior of Hydrogels and Microgels

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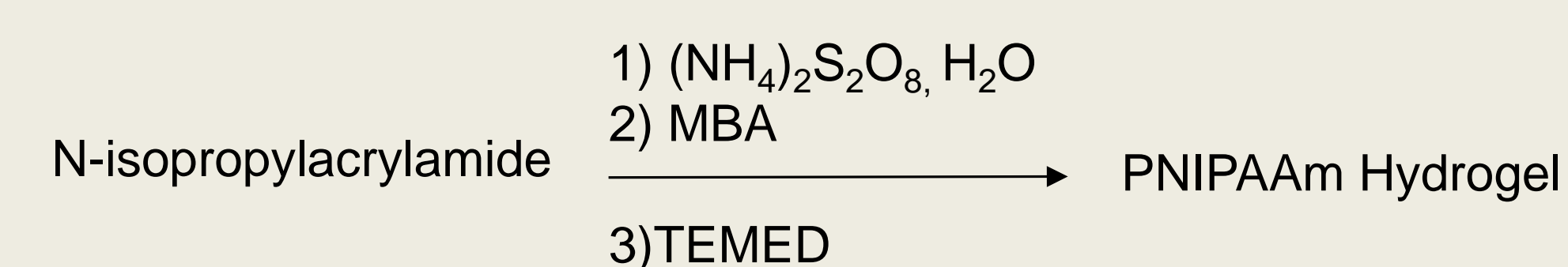
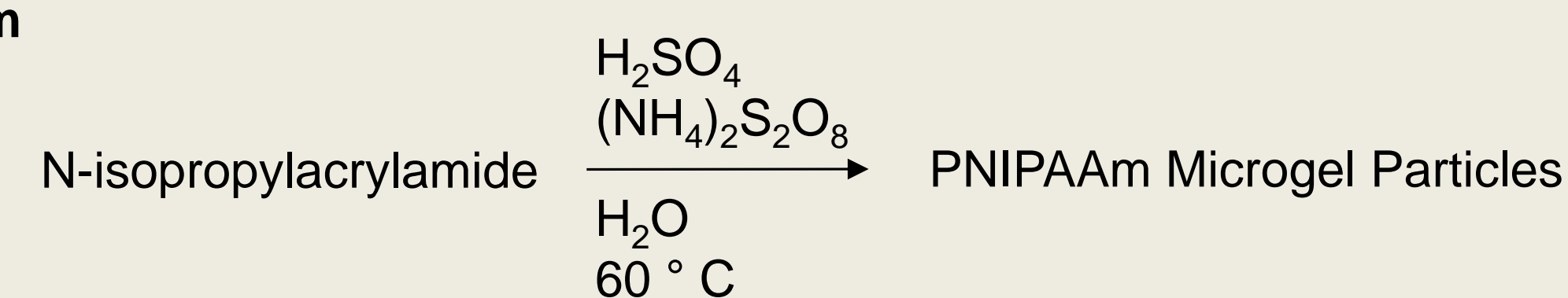


## BACKGROUND

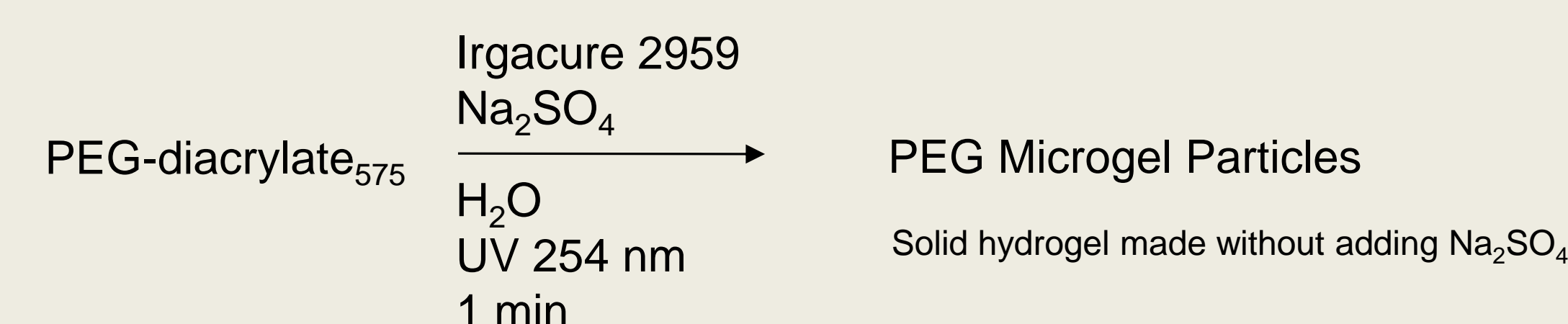
- Stimuli responsive hydrogel systems have been studied for many applications, particularly in the medical and biological
- For future soldiers, the Army has an interest in smart textiles capable of better managing a soldier's comfort by regulating moisture and thermal properties
- Hydrogel or microgel textile coatings are of interest particularly for cold weather and Arctic uniforms,
- The effect of extreme cold on gel responsiveness however is not well studied
- This project seeks to understand the effect of cold temperature (down to  $-80^{\circ}\text{C}$ ) on hydrogel and microgel particles properties and response to thermal stimuli
- We chose three common gel systems for study:
  - Poly N-isopropylacrylamide (PNIPAAm) LCST  $\sim 25\text{-}30^{\circ}\text{C}$
  - Polyethylene glycol (PEG)
  - Polyacrylic acid (PAA) UCST  $\sim 25\text{-}30^{\circ}\text{C}$

## HYDROGEL SYNTHESIS

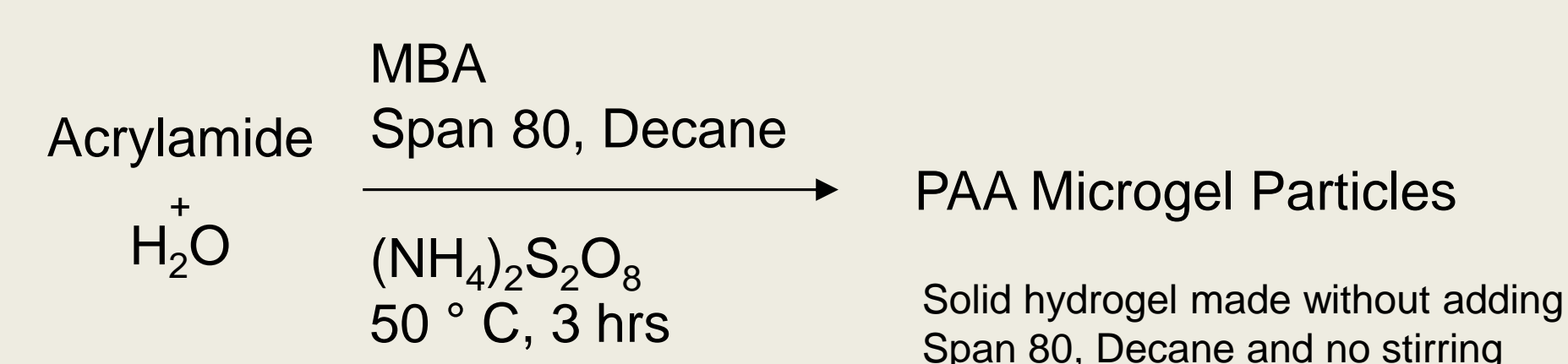
### PNIPAAm



### PEG



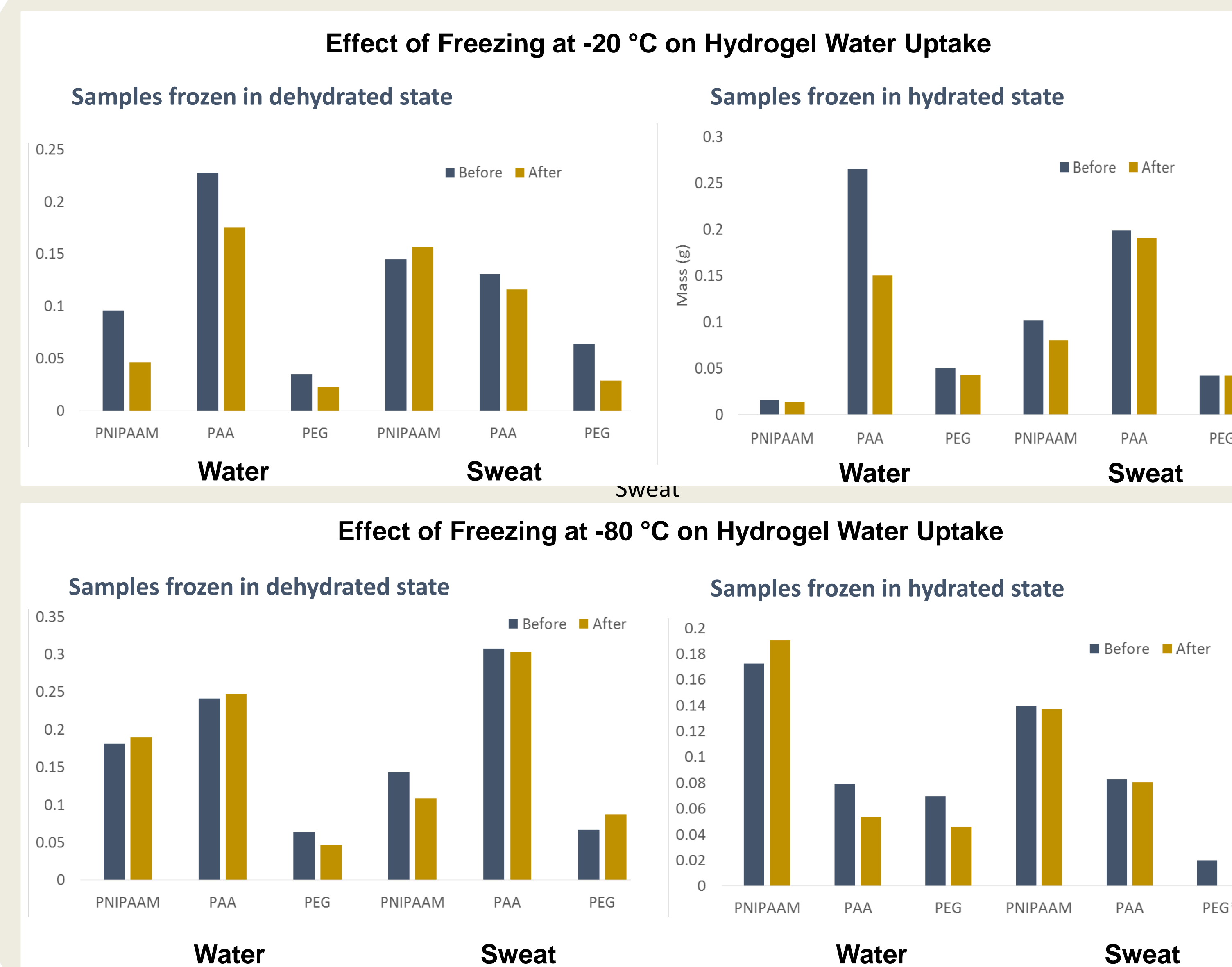
### PAA



## HYDROGEL COLD TREATMENT

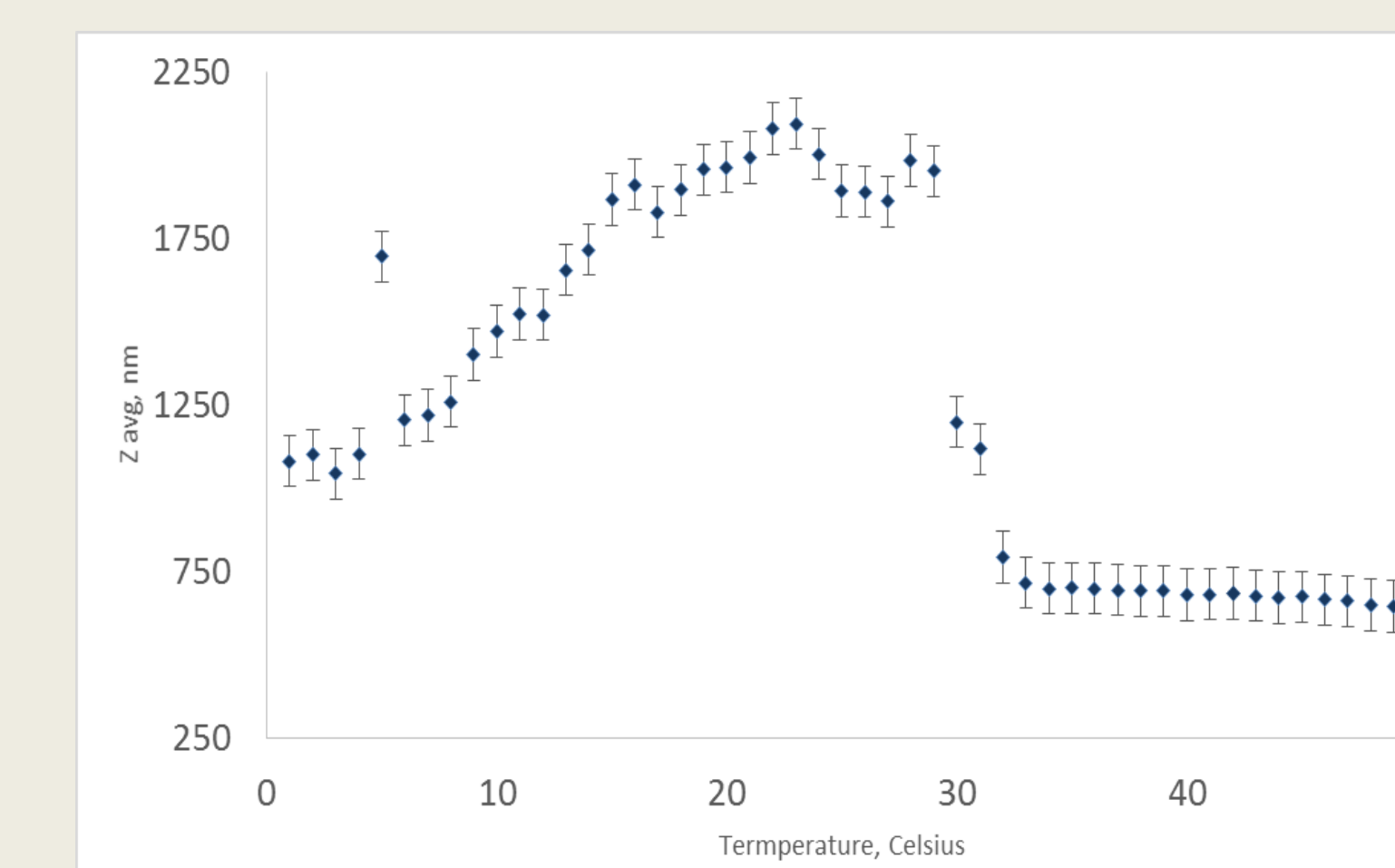
- Hydrogels were dried in an oven overnight
- Half the samples were rehydrated in water and artificial sweat solutions
- Dry and wet samples were frozen at  $-20^{\circ}\text{C}$  and  $-80^{\circ}\text{C}$  for 24 hours
- Samples were thawed to room temperature, dried, and rehydrated to determine water uptake post freezing

## EFFECTS ON WATER UPTAKE



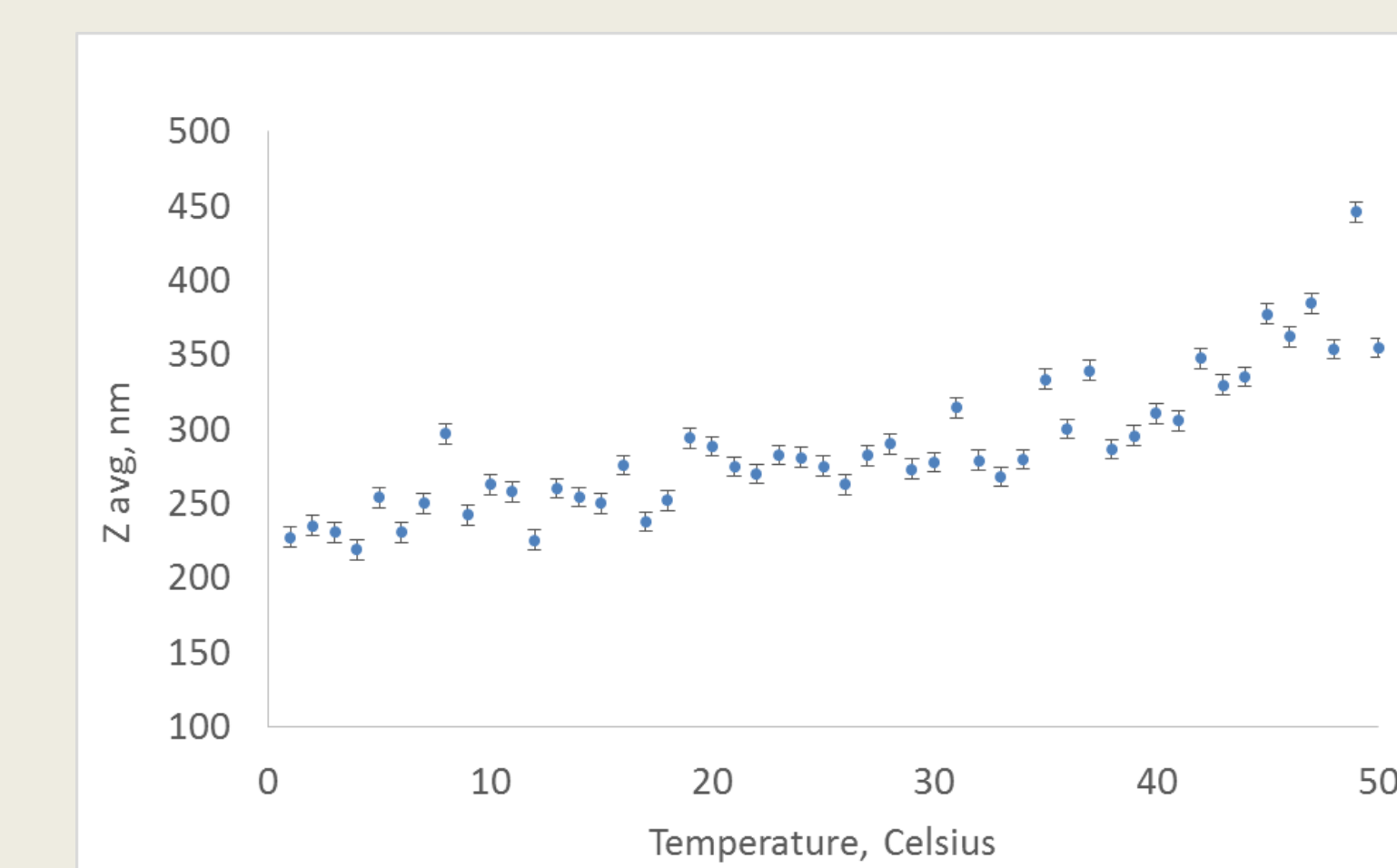
## PRELIMINARY MICROGEL THERMAL STUDIES

### PNIPAAm



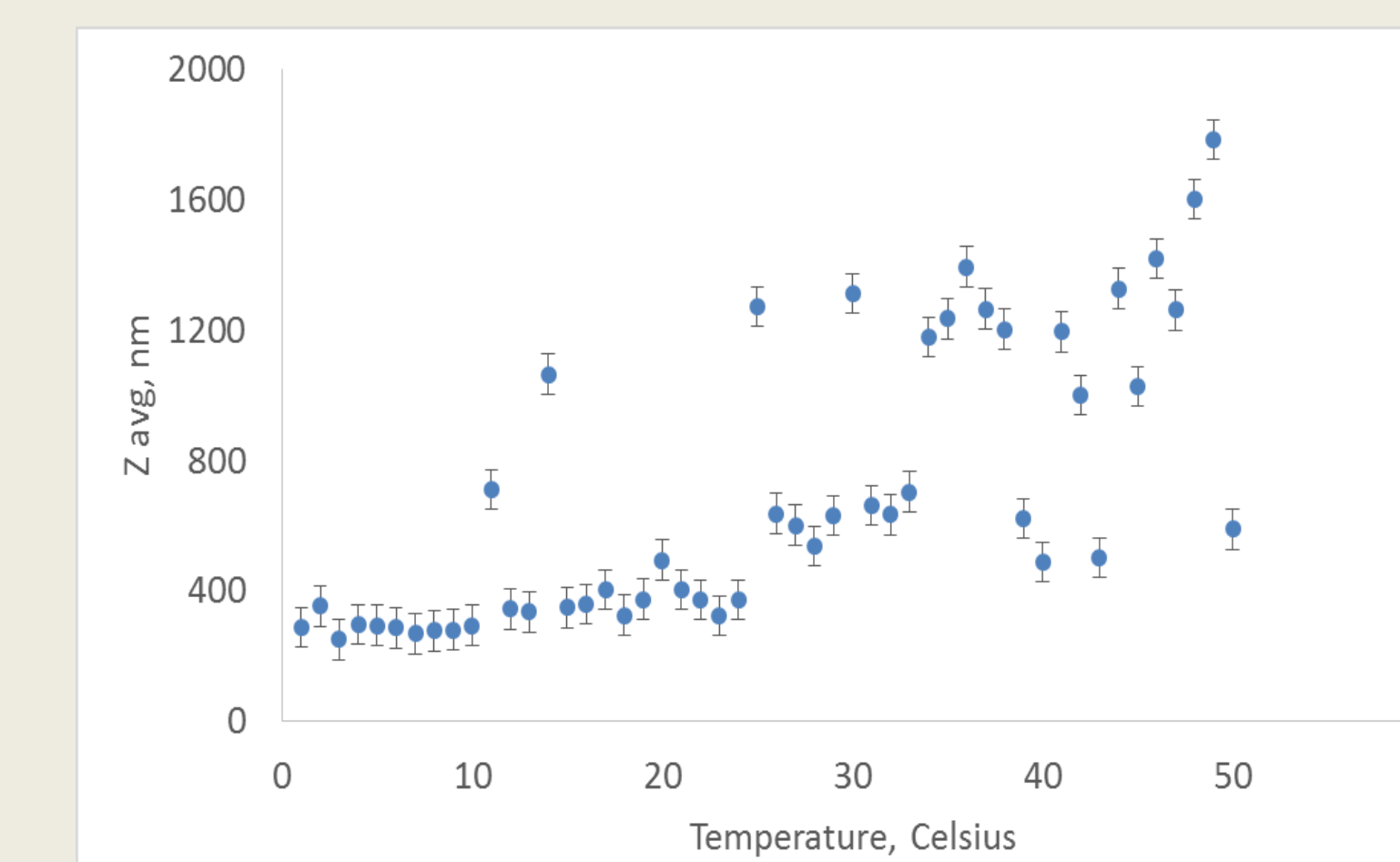
- PNIPAAm microgels are relatively homogenous,
- Show clear narrow LCST,
- Show size contraction near freezing

### PEG



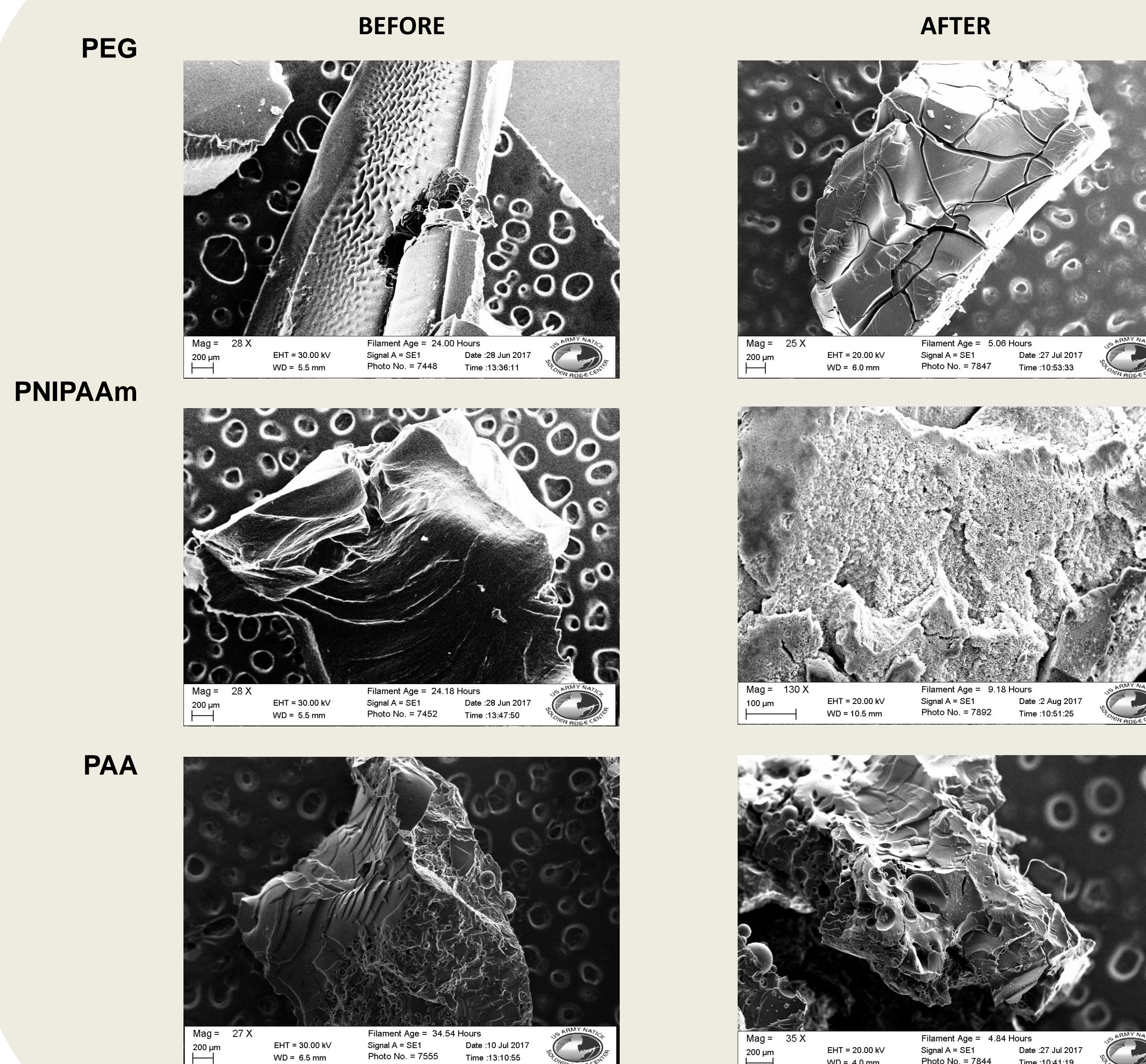
- PEG microgels are relatively homogenous
- Show little temperature effect on particle radius

### PAA



- PAA microgels are heterogeneous giving noisy DLS signal
- however phase transition is still visible

## MORPHOLOGY POST FREEZING



## FUTURE WORK

- Prepare more homogenous microgel particle samples
- Test water uptake of particles before and after freezing
- Study effect of cold exposure on sensitivity of response to thermal stimuli, understand contraction in PNIPAAm system and not other gels
- View microgel changes in real time with eSEM
- Coat microgel particles onto textile swatches for cold weather testing

## ACKNOWLEDGEMENTS

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